S
388.11
H3eb

STATE DOCUMENTS

MONTANA STATE HIGHWAY DEPARTMENT

HIGHWAY PLANNING SURVEY

IN COOPERATION WITH

PUBLIC ROADS ADMINISTRATION

****
****
****

ECONOMIC ANALYSIS OF THE PROPOSED BIG SANDY-HILGER FEDERAL AID SECONDARY ROUTING

February 1946

MONTANA STATE LIBRARY
930 East Lyndale Avenue
Helena, Montana 59601

Montana State Library
3 0864 1006 2276 3

MONTANA STATE HIGHWAY DEPARTMENT

HIGHWAY PLANNING SURVEY

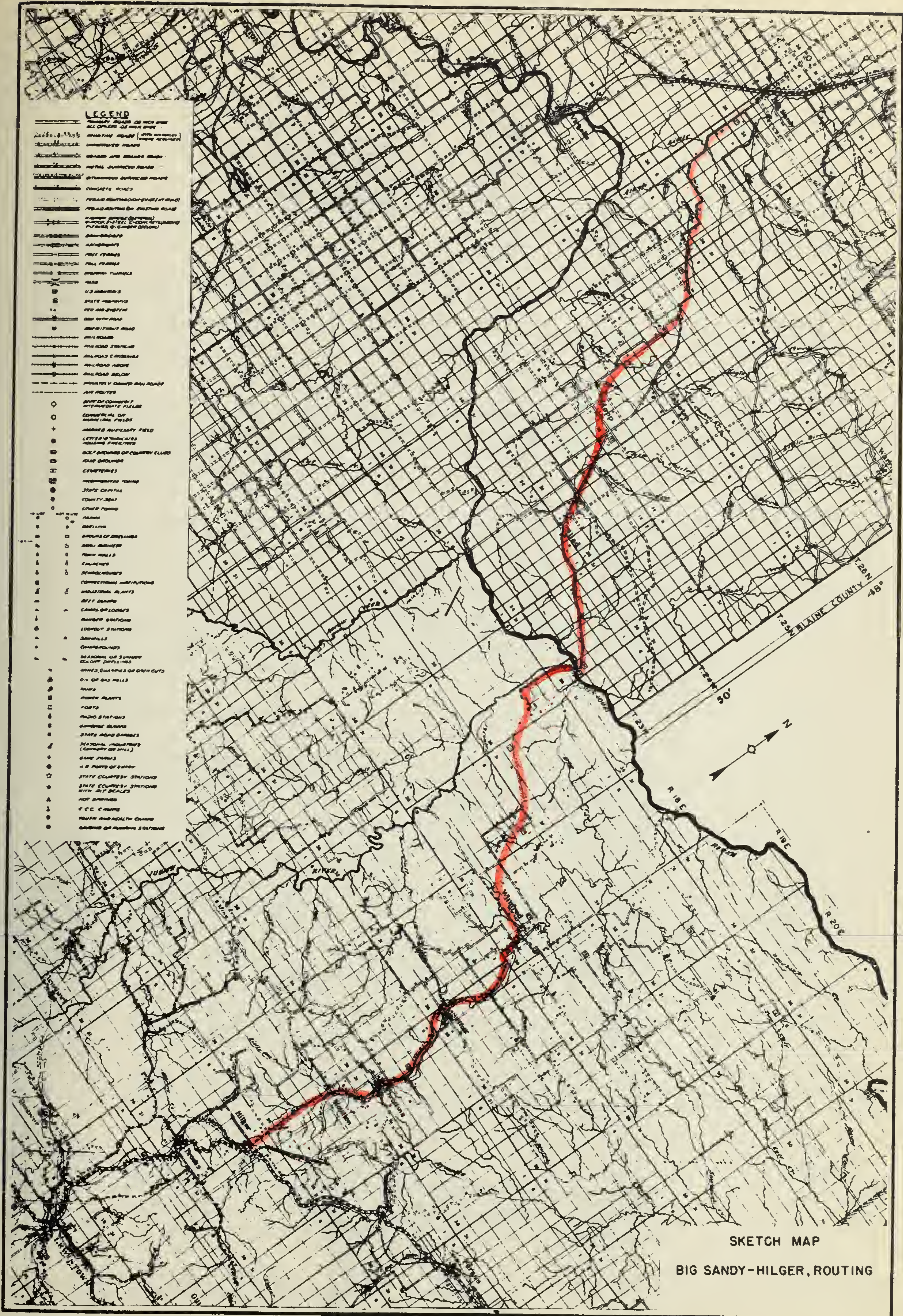
IN COOPERATION WITH

PUBLIC ROADS ADMINISTRATION

****
****
****

ECONOMIC ANALYSIS OF THE PROPOSED BIG SANDY-HILGER FEDERAL AID SECONDARY ROUTING

February 1946



SKETCH MAP

BIG SANDY-HILGER, ROUTING

Digitized by the Internet Archive
in 2012 with funding from
Montana State Library

http://archive.org/details/economicanaly2163mont

TABLE OF CONTENTS

Page

Map. . . . . Frontispiece

Basic Design Categories. . . . . i-ii

Guide For Estimating Traffic. iii

I. SUMMARY OF FINDINGS. 1-2

Influence of Great Falls as a trade-industry center -- existing travel routes -- premise for diversion.

II. ROUTE DESCRIPTION. 2-3

Terminals -- route distances -- topography -- surface type.

III. TRAFFIC DATA 4-6

Relationship of traffic and vocational pursuits -- average daily traffic, 1941, local -- average daily traffic, 1941, diverted.

IV. ECONOMIC ANALYSIS. 6-20

A. Annual Cost Calculations 6-9
Select Standard 0 -- construction cost experience in area -- basic costs -- derivation of construction costs per mile -- capitalization of construction costs on annual basis -- maintenance costs.

B. Average Daily Traffic, 1960. 9-10
1. Existing Traffic. 9
2. Diverted Traffic. 9
3. All Traffic 9
Classification of traffic by vehicle types. . . . 10

C. Annual Revenue 11-12
Source of basic data -- estimate of income, 1960.

D. Time Element Savings 13-14
Factors which operate to save time -- statement of time element savings.

E. Mileage Element Savings 14-17
Factors which operate to bring about mileage element savings -- statement of mileage element savings -- explanation and derivation of mathematical formulae.

F. Traffic Benefits 18
Allocation of benefits by function.

G. Derivation of Quotients 18-20
Explanation of variables involved in the derivation of the several quotients -- significance of each of the several quotients --

V. RECOMMENDATIONS 20

FAS No. 236, Fergus County and 351, Chouteau County, as presently designated, should be built to serve traffic of interest.

Montana State Highway Department
Traffic and Planning Section
Public Roads Administration
Basic Design Categories
Table No. 1

Standard	Average Daily Traffic	Classification	Max. Grade	Max. Curvature (Degree)	Sight Distance Non Passing: Horiz. Curvature (Degree)	Sight Distance Non Passing: Vertical Curvature (Algebraic Difference)	Sight Distance Non Passing: Feet	Sight Distance Passing: Feet	Shoulder Width	Width of Road Bed at Grade	Width of Surfacing	Minimum Type of Surfacing	Minimum Base Course
0	0-200	20 M 40	7	14	14		280	800	3	24	18	Under 1" Oil	5"
1	201-400	50 M 40	7	14	14		290	800	4	28	20	2" Oil	6"
2	401-800	100 M 40	7	14	14		310	1100	5	32	22	$2\frac{1}{2}$" Oil	8"
3	801-1800	200 M 40	7	14	14	SEE TABLE NO. 2.	320	1100	6	34	22	$2\frac{1}{2}$" Oil	8"
4	1801-3500	300 M 40	7	14	14		330	1100	8	38	22	$2\frac{1}{2}$" Oil	8"
5	0-200	20 M 60	6	6	6		460	1700	3	26	20	Under 1" Oil	5"
6	201-400	50 M 60	6	6	6		460	1700	4	30	22	2" Oil	6"
7	401-800	100 M 60	6	6	6		470	2100	5	32	22	$2\frac{1}{2}$" Oil	8"
8	801-1800	200 M 60	6	6	6		480	2100	6	34	22	$2\frac{1}{2}$" Oil	8"
9	1801-3500	300 M 60	6	6	6		500	2100	8	38	22	$2\frac{1}{2}$" Oil	8"

Note: Roads having over 3500 vehicles per day require special design.

TABLE NO. 2

Table giving length of vertical curve required for various Non - passing sight distances

December 18, 1943

Algebraic Difference between grades for convex curvature.	Length of vertical curve for a Non-passing sight distance of: 280 feet	Length of vertical curve for a Non-passing sight distance of: 290 feet	Length of vertical curve for a Non-passing sight distance of: 310 feet	Length of vertical curve for a Non-passing sight distance of: 320 feet	Length of vertical curve for a Non-passing sight distance of: 330 feet	Length of vertical curve for a Non-passing sight distance of: 460 feet	Length of vertical curve for a Non-passing sight distance of: 470 feet	Length of vertical curve for a Non-passing sight distance of: 480 feet	Length of vertical curve for a Non-passing sight distance of: 500 feet
1.00	96	103	117	125	133	258	269	281	305
2.00	191	205	234	250	266	516	539	562	610
3.00	287	308	352	375	398	774	808	843	915
4.00	382	410	469	500	531	1032	1078	1124	1220
5.00	478	513	586	624	664	1290	1347	1405	1524
6.00	574	615	703	749	797	1548	1616	1686	1829
7.00	669	718	820	874	930	1806	1886	1967	2134
8.00	765	820	938	999	1062	2064	2155	2248	2439
9.00	860	923	1055	1124	1195	2322	2425	2529	2744
10.00	956	1026	1172	1249	1328	2581	2694	2810	3049
11.00	1052	1128	1289	1374	1461	2839	2963	3091	3354
12.00	1147	1231	1406	1499	1594	3097	3233	3372	3659
13.00	1243	1333	1524	1623	1726	3355	3502	3653	3963
14.00	1339	1436	1641	1748	1859	3613	3771	3934	4268

MONTANA HIGHWAY PLANNING SURVEY

GUIDES FOR ESTIMATING 1960 TRAFFIC

			Applies to:
1.	100% =	1941 traffic.	
2.	110% to 125% =	Traffic if route is unimproved at present time but expected to be improved by 1960.	F.A., F.A.S. and Class 1, 2, & 3 Forest Highways. Applies to sparcely settled rural areas. (Add extra traffic generated by logging activities on timber utilization roads or other major industries and traffic induced by these activities).
3.	125% to 150% =	Traffic if route is unimproved at present time but expected to be improved by 1960.	F.A., F.A.S. and Class 1, 2, & 3 Forest Highways. Applies in checkerboard well-settled rural areas or on through-roads. (Add extra traffic generated by logging activities on timber utilization roads or other major industries and traffic induced by these activities).
4.	150% to 200% =	Traffic if route is unimproved at present time but expected to be improved by 1960.	F.A., F.A.S. and Class 1, 2, & 3 Forest Highways. This applies in exceptional cases such as bottlenecks and natural cutoffs. Some cases, of course, might be much more but these special conditions would require special analysis.
Note:		Date of expected improvement does not change traffic estimates for 1960.	(Add extra traffic generated by logging activities on timber utilization roads or other major industries and traffic induced by these activities).

130% = expected secular growth 1941 to 1960 -- to be applied to all above conditions except traffic generated by logging activities, or other major industries.

Applies to all roads now constructed. (Without any of above increases)

Average summer maximum traffic equals double average ADT except on predominately recreational routes where factor might be as high as 3.

Average summer maximum traffic equals average of several maximum summer days.

Maximum hour equals 10% of maximum summer ADT. (Usual public traffic), or 15 to 20% on roads used by both the public and by major logging operations or other major industries.

ECONOMIC ANALYSIS OF THE PROPOSED BIG SANDY-HILGER FEDERAL AID SECONDARY ROUTING

I. SUMMARY OF FINDINGS

As a result of the analysis brought out in detail in Section IV of this report, we know that secondary road construction along the route cited above is neither feasible nor profitable from the standpoint of highway finance.

Great Falls, as a financial and trade industry center exerts a considerable "pull" on all traffic through the central plains area of Montana to thus detract from the possibility of traffic being diverted from US 87-89, Lewistown - Great Falls and from Montana 29, Great Falls - Big Sandy in any considerable volume. Furthermore there is presently a designated secondary routing from Fort Benton, Chouteau County to Brooks, Fergus County, via Geraldine, Square Butte, Coffee Creek and Denton. This being the case, it must be assumed for purposes of this analysis that any traffic diverted from US 87-89 and Montana 29 must first be credited to the Fort Benton - Brooks routing. Given a time when the Hilger - Big Sandy routing is completed the benefits to diverted traffic along the routing will be computed on the basis of travel-distance saved from Brooks to Big Sandy via the proposed routing as compared to an existing travelled way from Brooks to Fort Benton and from Fort Benton to Big Sandy. The long way around, Brooks - Fort Benton - Big Sandy, is 139 miles, by way of the proposed improvement the distance will be 93 miles to thus effect a travel-distance saving of 46 miles.

Local traffic, farm to market and recreational, from Winifred to Coulee Creek, a distance of some 60 miles is of such low volume, 17 vehicles per day, as to render this section of the routing outside the scope of traffic

interest. Even though this volume were doubled as a consequence of normal growth and completion of a through route between Hilger and Lewistown (See Guide to Traffic Estimation) the low level section would not qualify for improvement to secondary system standards. The lowest level of traffic is of course at the Missouri River Crossing, 11 vehicles per day, and there is not much basis to believe that this volume of traffic will increase greatly should a bridge be erected there; farm-grazing traffic on the north side of the river near Big Sandy will continue to and through that town in search of a trade outlet. Lewistown exerts a similar influence on that traffic which is now generated south of the river between the river and Winifred. In summary, the local traffic plus the traffic which will be diverted to the route will not now, nor in the future, qualify the routing for improvement for the whole distance between Hilger and Big Sandy.

The following sections of this report will support and substantiate the findings cited hereabove.

II. ROUTE DESCRIPTIONS

The route as proposed for improvement comprises two designated sections of the Federal Aid Secondary System, FAS No. 236, Hilger to Winifred and west; 34 miles, and FAS No. 351, Big Sandy South, 7 miles; and that undesignated interval, 47 miles, lying between the terminals cited immediately herebefore. Beginning at Hilger, on FA Primary Routing No. 43, the road follows the present travelled way, county road, through Moulton, Christina and Suffolk to Winifred, a distance of 26 miles. The road turns west on leaving Winifred, following a county road for about 8 miles to terminate FA Secondary Routing No. 236. From the last mentioned point, the route as proposed for analysis follows existing county roads to the southerly extremity of FA Secondary Routing No. 351 via the Lohse Ferry, Illiad, Hopp, and Coulèe

Creek, a distance of 53 miles. The remaining interval, 7 miles in length, follows existing county roads to Big Sandy and, as cited herebefore, comprises FA Secondary Routing No.351.

The routing from Hilger to Winifred traverses a comparatively densely populated rural area and the road is now an important truck feeder route in the Fergus County system of rural roads. From Winifred west to the "breaks" of the Missouri the land is devoted principally to a grazing economy with commensurately low population levels.

On leaving the Missouri River at Lohse Ferry to enter Chouteau County the routing again traverses a grazing area until it passes Coulee Creek where it enters a "hard-grain" and hay area with a corresponding higher population level which develops progressively as it nears Big Sandy.

There are no untoward features of terrain which might impose difficulty in the construction of the routing except in the vicinity of the Missouri River Crossing - here the road traverses the fabled "breaks" of the Missouri with a possibility of increased quantities of material involved in grading operations.

Since this crossing is below the stated "Head of Navigation" at Fort Benton, the bridge will require a 38 foot clearance above high water.

The existing road is gravel surfaced from Hilger to Winifred and 4 miles beyond - from this point to a point some 5 miles north of Hopp the road is either unimproved or graded and drained - the balance of the route, 23 miles, is gravel surfaced.

In view of the traffic volume which is estimated for 1960, the routing will be analyzed as though it were built to Standard No. 0 (See Basic Design Categories, pages i and ii)

III. TRAFFIC DATA

Traffic and vocational pursuits are inter-related to a remarkable degree - this does not mean that there is a true dollar relationship between the two variables. However, the relationship is binding enough for us to say that traffic records are indicative of economic trends and the fluctuations in such records are evidence of similar rise and fall in the economic pattern of the area being studied. By so treating with the economy of the area along a given routing, we thus avoid manipulation of business and production statistics; our traffic records will suffice. It remains for us, however, to label the existing traffic and that which will develop in the future in terms of the economic function which prompts, such traffic.

Here as in other rural areas of Montana, the economy is based chiefly on farm-grazing. In those areas adjoining and contiguous to Big Sandy and Winifred - Hilger, hard grains provide the principal or basic income, in other areas; stock-raising, both cattle and sheep, provide the principal income - related traffic in terms of volume is less than that manifest in the areas devoted to a cash grain economy. In both cases, the traffic is consistent and sustained and not subject to any great fluctuation from year to year. As of 1941, the last normal traffic year, before this nation entered World War II, the average traffic classified by vehicle type between Big Sandy and Hilger was as follows:

Average Daily Traffic, Big Sandy-
Hilger In 1941

Vehicle Type	Average Daily Traffic
Passenger Cars, Local	28.6
Passenger Cars, Foreign	0.7
Passenger Cars, All	29.3
Light Trucks	15.9
Medium Trucks	0.4
Heavy Trucks	0.0
Trac. Tks. & Semi-trlrs.	0.4
Tks. & Full Trailers	0.2
Busses	0.4
All Trucks & Busses	17.3
All Traffic	46.6

Basic data used in the preparation of this tabulation derive from traffic records maintained at Hilger, Christina, Suffolk, Winifred, 2 points strategically located west of Winifred, Lohse Ferry, Illiad, Hopp, Coulee Creek, 2 junctions along FAS No. 351 and at Big Sandy - data in re classification derive from studies conducted at Box Elder and Brooks. So much for traffic which now uses the Big Sandy - Hilger routing.

Aside from local aspects of the problem we have the possibility of diversion to the route, should it be built. From data originating at study points near Box Elder and Hobson we find that as of 1941 there are about 24 passenger cars that might possibly divert to the Big Sandy - Lewistown routing. In consideration of the "pull" of the Great Falls trade - industry area it is probable that these vehicles would use the cut-off only 50% of the time - the effective passenger car diversion as of 1941 was then listed at 11 local cars and 1.3 out-of-state cars.

It was estimated that commercial traffic, trucks and busses, would divert in the same ratio, trucks to passenger cars, as that in evidence at study points west of Lewistown and at Box Elder. The total estimated average daily diversion as of 1941 would then be as follows:

Estimated Average Daily Traffic Which
Will Divert To The Big Sandy-Lewistown Routing As of 1941

Vehicle Type	Average Daily Traffic
Passenger Cars, Local	11.0
Passenger Cars, Foreign	1.3
Passenger Cars, All	12.3
Light Trucks	2.1
Medium Trucks	0.2
Heavy Trucks	0.1
Trac.-Tks. & Semi-trlrs.	0.4
Tks. & Full Trailers	0.1
Busses	0.2
All Trucks & Busses	3.1
All Traffic	15.4

The analysis which follows is predicated on possibilities which might obtain in 1960 - but we do not know of, nor do we attempt herein to forecast the 1960 economy of Fergus and Chouteau Counties and the areas contiguous thereto. However, we have recourse to traffic trends and patterns, which, as we have stated hereinbefore, are almost synonymous and equally effective with economic trends. The patterns and basis of traffic estimation, in other words, are liberal and comprehensive enough, we believe, to provide for any fundamental or basic change of the economy in any given area.

This discussion leads to the preparation of the economic analysis- the data are now assembled, as follows, to allow us to draw specific conclusions in reference to the economic feasibility of building the Big Sandy - Hilger routing in whole.

IV. ECONOMIC ANALYSIS

Now to list costs and benefits to afford a basis of comparison.

A. Annual Cost Calculations

It is assumed, as stated before, that this routing will be built to conform with Standard No. 0 for the reason that oil surfacing will thus be provided as an attraction for the diversionary traffic. It is to be noted that the estimated daily traffic as developed hereinafter would recommend that choice. Costs would approximate those experienced in the construction of the Denton-Brooks road and the Fort Benton - Geraldine road, due allowance being made, of course, for a probable increase in construction costs in the post-war period. Basic costs in reference to the above cited intervals are as follows:

BASIC CONSTRUCTION COSTS

Denton-Hilger

Project No.	Year	Length	Grading	Minor	Major	Gravel Base & Surface	Engineering	Administration	Right-of-Way
309	1934	4.099	$11,343	$1928		$8854	$3326	$340	$3439
309	1934	0.025			$8931		$454	$111	
309B	1935	3.087	$12,202	$4970		$7645	$2389	$831	
309B	1935	0.014			$3303		$296	$114	
342A	1936	3.114	$16,932	$6109		$11,409	$2174	$649	$3210
342B	1940	3.125	$5,062	$2661		$7142	$2980		
Fort Benton - Southeast									
290	1934	1.781	$17,443	$1742		$5,664	$951	$315	$754
290	1934	0.018			$4,162		$225	$52	
290B	1935	3.438	$17,564	$2364		$9996	$4933	$1134	$1454
290B	1935	0.004			$1,455		$240	$55	
290C	1939	1.888	$9,747	$1464		$8514	$2448		
290C	1939	0.014			$4549		$498		
290D	1941	4.986	$8,871	$4438			$2303		
290D	1941	0,007			$2350		$407		
Averages, Denton-Hilger		7.186	$3277	$960	$1702	$2296	$900	$194	$479
Averages, Denton-Hilger		10.300	$3929	$1263		$2710	$766	$199	$646
Averages, Denton-Hilger		13.425	$3392	$1167		$2611	$810		
Averages, Ft. Benton SE		5.219	$6708	$787	$1076	$3000	$1217	$298	$423
Averages, Ft. Benton SE		7.107	$6297	$784		$3401	$1172		
Averages, Ft. Benton SE		12.093	$4434	$828			$879		
General Averages		12.405	$4720	$914	$1482	$2592	$1033	$238	$455
General Averages		25,518	$3886	$1006			843		

Drawing on these data we have estimated construction costs per mile for road work on the Big Sandy - Hilger routing as follows:

Grading	$4,500
Minor Drainage Structures	1,200
Small Bridges, Treated Timber	1,500
Gravel Base & Surface	3,500
Oil Surfacing	1,250
Engineering & Administration	1,250
Right-of-Way	600
Sub-Total	$13,800
+ 10% for contingencies	1,380
	$15,180

The total estimated cost for all construction items other than the Missouri River Bridge would be $1,335,840, (88 x $15,180). It is estimated that this bridge will cost in the neighborhood of $400,000, this charge to cover all costs, engineering, construction, administration, etc., incident to the erection of the bridge to render a total construction cost at $1,735,840, ($1,335,840 + $400,000).

It is generally believed that traffic will demand or require roads of higher standard as time goes on to thus require a greater outlay on reconstruction. Interest charges should be assigned in recognition of this feature - in other words, the road "as built" should lay up a reserve to meet increased construction costs in the future. Accordingly, the Missouri River Bridge costs have been assigned an interest charge of 2½%, the principal and interest to be amortized in 40 years -- the other costs have been assigned an interest charge of 2½% also, however the amortization period has been halved. In both cases, the amortization time interval is deemed to be

significant of the economic service life of the component construction features. The total annual capital cost would then be as follows:

Missouri River Bridge, $400,000 x 0.0398	=	$15,920
Other Construction Items, $1,335,840 x 0.0641	=	85,627
Total Annual Capital Cost for Construction	=	$101,547

It is estimated that an average charge of $150 per mile per year will take care of all costs incident to the upkeep of the road way and the bridge to bring the maintenance costs to $13,200 yearly. This when added to the annual capital cost of construction gives us a total annual capital cost of $114,747.

B. Average Daily Traffic, 1960

1. Existing Traffic

To arrive at a figure for 1960 traffic, we have added 50% to allow for the usual increase on completion of a through route and 30% to allow for normal traffic growth. (See Guide to Traffic Estimation, page iii).

2. Diverted Traffic

With reference to that traffic which might conceivably be diverted to the project, we have added 30% to the 1941 figure to thus allow for normal traffic growth.

3. All Traffic

The total estimated average daily traffic over the length of the route as of 1960 is as follows:

Estimated Average Daily Traffic
Big Sandy-Hilger as of 1960

Traffic Category and Vehicle Type	1941	+ 50% on Completion of Through Route	+ 30% to Allow for Normal Traffic Growth 1960
Existing Traffic			
Passenger Cars, Local	28.6	42.9	56.0
Passenger Cars, Foreign	0.7	1.0	1.0
Passenger Cars	29.3	43.9	57.0
Light Trucks	15.9	23.9	31.0
Medium Trucks	0.4	0.6	0.9
Heavy Trucks	0.0	0.0	0.2
Trac. Tks. & Semi-Trailers	0.4	0.6	0.7
Tks. & Full Trailers	0.2	0.3	0.4
Busses	0.4	0.6	0.8
All Trucks & Busses	17.3	26.0	34.0
All Traffic	46.6	69.9	91.0
Diverted Traffic			
Passenger Cars, Local	11.0		14.3
Passenger Cars, Foreign	1.3		1.7
Passenger Cars,	12.3		16.0
Light Trucks	2.1		2.9
Medium Trucks	0.2		0.2
Heavy Trucks	0.1		0.1
Trac. Tks. & Semi-Trailers	0.4		0.5
Tks. & Full Trailers	0.1		0.1
Busses	0.2		0.2
All Trucks & Busses	3.1		4.0
All Traffic	15.4		20.0
All Traffic			
Passenger Cars, Local	39.6		70.3
Passenger Cars, Foreign	2.0		2.7
Passenger Cars	41.6		73.0
Light Trucks	18.0		33.9
Medium Trucks	0.6		1.1
Heavy Trucks	0.1		0.3
Trac. Tks. & Semi-trailers	0.8		1.2
Tks. & Full Trailers	0.3		0.5
Busses	0.6		1.0
All Tks. & Busses	20.4		38.0
All Traffic	62.0		111.0

C. Annual Revenues

To arrive at an estimate of annual revenues the traffic data were resolved into vehicle miles and then into ton miles. These data were extended on the basis of unit net revenues per ton mile to arrive at an estimate of the total annual revenue. Unit net revenues derive from a general study conducted by this department. Average gross ton figures for each class of vehicle were also ascertained in the course of research work of the Planning Survey. Tabulation is on the following page.

HIGHWAY PROJECT ANALYSIS

Location of project Montana Description of project Big Sandy-Hilger County Fergus & Chouteau
Highway FAS Nos. 236 & 351 Extended Highway System FA Secondary Length 88 miles Date of analysis February 1946

Traffic Type	Average Annual Traffic: Existing Traffic: Vehicles	Average Annual Traffic: Existing Traffic: Tons	Average Annual Traffic: Diverted Traffic: Vehicles	Average Annual Traffic: Diverted Traffic: Tons	Average Annual Road Use During Life of Project: Ton Mile	Unit Net Revenues Per Ton Mile	Total Annual Net Revenue
Passenger Cars - Montana	20,440	30,660	5,220	7,830	3,387,120	0.002188	$7,411
Passenger Cars - Foreign	365	548	620	930	130,064	0.001799	234
Total passenger cars	20,805	31,208	5,840	8,760	3,517,184		7,645
Trucks, light	11,315	37,000	1,059	3,463	3,560,744	0.003248	11,565
Trucks, medium	329	2,263	73	502	243,320	0.002382	580
Trucks, heavy	73	814	37	413	107,976	0.001619	175
Trucks, semi-trailer	255	3,764	182	2,686	567,600	0.001543	876
Trucks, full-trailer	146	3,342	36	824	366,608	0.001396	512
Busses,	292	2,628	73	657	289,080	0.001873	541
Total trucks & busses	12,410	49,811	1,460	8,545	5,135,328		14,249
Total all vehicles	33,215	81,019	7,300	17,305	8,652,512		

Average weight of trucks 4.207 tons; All vehicles 2.427 tons. Total Annual Income....$ 21,894

Percentage truck traffic 34.23% .

Amortization period 20 years and 40 years.

D. Time Element Savings

Time element savings accrue to traffic as a circumstance of surface and alignment improvements and because of shortened travel distance. In this particular case, the Existing Traffic will be able to travel at accelerated speeds due to surface and alignment improvements and the time consumption will be decreased because of a significant decrease in travel distance, 6 miles. The Diverted Traffic, will be benefited by a travel-distance saving of 43 miles between Brooks and Big Sandy - the speed rate will remain the same as at present because the surface type via present travelled roads will be equal to that built on the proposed routing. Composite time element savings are tabulated hereinafter. The "New" speed rates originate with study data of the Oregon Highway Department and coincide with speeds recommended in Standard No. O. The "Old" speed rates conform to those established in the course of the Oregon study.

Time Element Savings

HIGHWAY PROJECT ANALYSIS

Location of project Montana County Fergus & Chouteau
Description of project Lewistown - Big Sandy
Highway number FAS Nos. 236 & 351 Extended Highway System FA Secondary
Length 88 miles Date of analysis February 1946

	Existing Traffic		Diverted Traffic	
Annual Traffic Volume	New	Old	New	Old
Private Passenger cars (per year)	20,805		5840	
Trucks, light (per year).........	11,315		1059	
Trucks, medium (per year)........	329		73	
Trucks, heavy (per year).........	766		328	
Totals...............	33,215		7300	
Private Passenger Cars				
Average speed (miles per hour)...	43	35	43	43
Distance (Miles).................	88	94	93	139
Time (hours per trip)............	2.047	2.686	2.163	3.233
Time savings per vehicle.........	0.639		1.070	
Value of savings ($/vechicle-hour)	$0.60		$0.60	
Annual traffic volume............	20,805		5840	
Totals	$ 7,977			$ 3,749

Time Element Savings (Cont.)

	Existing Traffic		Diverted Traffic	
Trucks, Light	New	Old	New	Old
Average speed (miles per hour)..	39	31	39	39
Distance (miles)...............	88	94	93	139
Time (hours per trip)...........	2.256	3.032	2.385	3.564
Time savings per vehicle.........	0.776		1.179	
Value of savings ($/vehicle-hour)	$0.86		$0.86	
Annual traffic volume............	11,315		1059	
Totals...............	$ 7,551		$1,074	
Trucks, Medium				
Average speed (miles per hour)..	35	27	35	35
Distance (miles)...............	88	94	93	139
Time (hours per trip)...........	2.514	3.481	2.675	3.971
Time savings per vehicle.........	0.967		1.314	
Value of savings ($/vehicle-hour)	$1.17		$1.17	
Annual traffic volume............	329		73	
Totals...............	$ 372		$112	
Trucks, Heavy				
Average speed (miles per hour)..	32	24	32	32
Distance (miles)...............	88	94	93	139
Time (hours per trip)...........	2.750	3.917	2.906	4.344
Time savings per vehicle.........	11.167		1.438	
Value of savings ($/vehicle-hour)	$1.47		$1.47	
Annual traffic volume............	766		328	
Totals...............	$1314		$693	
Total Each Category.........	$17,214		$5,628	
TOTAL ANNUAL TIME ELEMENT SAVINGS..........			$ 22,842	

E. Mileage Element Savings

Mileage element savings, involving considerations of surface type, alignment, and decrease in travel distance, are functional aspects of road use and road construction. These several listed improvements operate to decrease "wear and tear" on engines and tires; they make a gallon of gas stretch farther. Procedures based on methods in use by the Oregon Highway Department are explained in notes set forth, thus 1/, 2/, etc.

Mileage Element Savings

HIGHWAY PROJECT ANALYSIS

Location of project Montana County Fergus & Chouteau
Description of Project Big Sandy - Hilger
Highway number Fas Nos. 236 & 351 Extended Highway System FA Secondary
Length Date of analysis February 1946

	Existing Traffic		Diverted Traffic	
Distance	New	Old	New	Old
Length (miles) 1/.............	88	94	93	139
Distance saving (miles).........	6		46	
Average annual traffic (tons)...	81,019		17,305	

Mileage Element Savings (CONT.)

HIGHWAY PROJECT ANALYSIS

	Existing Traffic			
Distance (cont.)	New	Old	New	Old
Annual traffic saving (ton-mi.)	486,114		796,030	
Cost ($/ton-mile)...............	$0.0193		$0.0194	
Totals...............	$ 9,382		$15,443	
Surface				
Roadway surface type 2/......	0.03	0.28		
Saving coefficient...........	0.25			
Aver. annual traffic (ton-mi.)	7,615,786			
Saving ($/ton-mile)...........	0.0048			
Totals...............	$36,556			
Alignment 3/				
Curvature rating..............	10	0		
Points improvement............	10			
Saving (point-ton-miles)......	76,157,860			
Saving ($/point-ton-mile).....	0.0001			
Totals...............	$7,616			
Total Each Category.........	$53,554		$15,443	
TOTAL ANNUAL MILEAGE ELEMENT SAVINGS...............			$ 68,997	

1/ Distance

Existing Traffic

Length (miles)

The present travelled way via existing county roads is 94 miles -- it is presumed that the over all travel distance will be decreased by at least 6 miles as a consequence of improved alignment.

Distance Saving

Subtract the "new" mileage from the "old" mileage.

Average Annual Traffic (tons)

Multiply the average daily traffic by 365 by the average gross weight of each traffic component. Average gross weights are as follows:

Passenger Cars,	1.5 tons	Trac. Tks. & Semi-trlrs.	14.76 tons
Light Trucks,	3.27 tons	Trucks & Full Trailers,	22.89 tons
Medium Trucks,	6.88 tons	Busses,	9.00 tons
Heavy Trucks,	11.15 tons		

Annual traffic saving (ton-mile)

Multiply the average annual traffic in tons by the distance saving in miles. Cost ($/ton-mile).

Find percentage of trucks thus:

$$\frac{\text{No. of trucks}}{\text{All Traffic}} = \frac{12{,}410}{33{,}215} = 37.4\%$$

Find average gross weight trucks thus:

$$\frac{\text{Gross Weight of trucks}}{\text{Number of Trucks}} = \frac{49{,}811}{12{,}410} = 4.014 \text{ tons} = 8{,}028 \text{ lbs.}$$

From Figure 113 of the Oregon Technical Bulletin we find that the truck mileage element operating cost for a truck of gross weight 8,028 lbs. is $0.0170 per ton mile. Similar costs for passenger cars are listed at $0.0207 per ton mile. Combining these costs in the proportions manifest in this particular category of traffic we have an operating cost of $0.0193 per ton mile. See below:

Passenger Cars,	(62.6%) =	0.626 x $0.0207 =	$0.0130
Trucks,	(37.4%) =	0.374 x 0.0170 =	0.0063
	Combined Costs per ton mile	=	$0.0193

Diverted Traffic

Length (miles)

From Brooks to Big Sandy by way of the present travelled way (Denton - Fort Benton) the over-all distance is 139 miles. By way of the proposed routing the distance will be 93 miles.

Distance saving (miles)

Subtract the "new" mileage, 93 from the "old" mileage, 139.

Average Annual Traffic (tons)

Per methods outlined in discussion of "Existing Traffic".

Annual Traffic Saving (ton-mile)

By procedures outlined in similar discussion, "Existing Traffic"

Cost ($/ton-mile)

Find trucks to be 20% of total traffic

Find average gross weight trucks to be 11,706 lbs. and the operating cost therefor to be $0.0142 per ton mile.

Combining costs in proportion manifest in the category of traffic we have results as follows:

Passenger Cars, (80%), 0.80 x $0.0207 = $0.0166
Trucks, (20%), 0.20 x 0.0142 = 0.0028
Combined operating cost $0.0194

2/ Surface

Existing Traffic

Assign a coefficient rating 0.28 to surface type as now in effect from Big Sandy to Hilger in accord with procedures advanced by the Oregon Highway Department. The improved route will be oil surfaced with a coefficient rating of 0.03 -- the difference between this coefficient rating and existing coefficient rating, 0.28, represents the saving coefficient, 0.25. This saving coefficient when applied to the operating cost per ton mile, $0.0193 gives us the saving per ton mile effected by the improvement in surface type.

3/ Alignment

Existing Traffic

Assume that the routing as it now exists to have a curvature rating of zero and that by construction of the route to standard type it will have a curvature rating of 10; the points improvement will thus be 10. Alignment, under this heading does not apply solely to straightaway layout - other factors enter in to the picture such as super elevation, adequate sight distance, passing distance etc., all of which contribute to a decrease in operating costs

F. Traffic Benefits

This tabulation involves an allocation of benefits, non-fuel function and fuel function, in accord with the proportions advanced by the Oregon Highway Department. (See Technical Bulletin No. 7).

HIGHWAY PROJECT ANALYSIS

Traffic Benefits

Location of project Montana County Fergus & Chouteau
Description of project Big Sandy -Hilger
Highway number FAS Nos. 236 & 351 Extended Highway System FA Secondary
Length 88 miles Date of Analysis February 1946

Mileage Element Factors

Item			Fuel Function	Non-fuel Function
Distance savings	$24,825	38%	$ 9,434	$ 15,391
Roadway surface savings	36,556	41%	14,988	21,568
Alignment savings	7,616	50%	3,808	3,808
Total Mileage Savings	$68,997		$28,230	$ 40,767

Time Element Factors

Type of Traffic	Annual Value of Time Savings
Passenger Cars	$ 11,726
Trucks, light	8,625
Trucks, medium	484
Trucks, heavy	2,007
Total Time Savings	$ 22,842

Recapitulation of Annual Benefits

Total Fuel Function Benefits			$ 28,230
Non-fuel function benefits	(Mileage element factors	$ 40,767	
	(Time element factors	22,842	
Total non-fuel Function Benefits			$ 63,609
TOTAL ANNUAL BENEFITS			$ 91,839

G. Derivation of Quotients

With such factual data as we now have at hand we are prepared to draw out certain conclusions in reference to the economic solvency of the Big Sandy - Hilger Routing.

HIGHWAY PROJECT ANALYSIS

Location of project Montana County Fergus & Chouteau
Description of project Big Sandy - Lewistown
Highway number FAS Nos. 236 & 351 Extended Highway System FA Secondary
Length 88 Miles Date of Analysis February 1946

I_{ar} = $ 21,894 1/ K_1 = 1.00
C_a = $ 114,747 2/ K_2 = $5,868/$28,230 = 0.21
B_n = $ 63,609 3/ K_3 = 0.05/0.20 = 0.25
B_f = $ 28,230 K_2K_3 = 0.21 x 0.25 = 0.05
4/ K_1C_a = $ 114,747 $1-K_2K_3$ = 1.00 - 0.05 = 0.95

5/ $Q_s = I_{ar}/K_1C_a$ = 21,894/114,747 = 0.19
6/ $Q_{Bn} = B_n/K_1C_a$ = 63,609/114,747 = 0.555
7/ $Q_{Bf} = B_f/K_1C_a$ = 28,230/114,474 = 0.245
8/ $Q'_s = Q_s - K_2K_3Q_{Bf}$ = 0.19 - 0.05 x 0.245 = 0.19 - 0.01 = 0.18
9/ $Q_c = 0.707\ (Q_s + Q_{Bn} + Q_{Bf}(1-K_2K_3)$ = 0.707 (0.19 + 0.555 + 0.245 x 0.95)
= 0.707 (0.19 + 0.555 + 0.23)
= 0.707 x 0.975
= 0.69

1/ The constant K_1 represents the pro rata cost chargeable to Road User funds, the Gasoline License Tax in this case.

2/ The constant K_2 represents the proportion of the total fuel function savings which derives from use of the routing by the diverted traffic. In this particular instance the fuel savings for the diverted traffic would be $5,868, ($15,443 x 0.38), and this figure divided by the total fuel savings, $28,230 gives us the proportion which we are seeking.

3/ The constant K_3 represents the ratio of fuel tax to the total cost of fuel. As a matter of interest, if we take the fuel savings accruing to

the diverted traffic, \$5,868 and multiply by this factor, we have a resultant \$1,467, the net decrease in gas tax revenues for the Brooks - Fort Benton - Big Sandy highway. This to illustrate the necessity for the derivation of this constant in highway economic studies.

4/ By applying the constant K, to the annual capital costs we find that pro rata cost payable out of road-user funds.

5/ Q_s represents the solvency quotient - in this case the routing will "earn" 19% of the annual capital cost.

6/and 7/Q_{B_n} and Q_{B_f} represent the benefit quotients, non-fuel and fuel. Note that these benefits together equal 80% of the annual capital costs.

8/ Q'_s is the corrected solvency quotient - the Big Sandy - Hilger routing if built and thus entered in the Montana Highway picture will act, as stated herebefore, to decrease the revenues of the routing from which traffic will be diverted. Q'_s represents the net solvency of the proposed improvement in respect to other parts of the highway system.

9/ Q_c represents the composite quotient. Heretofore we have determined financial solvencies, now we compare benefits with revenues to ascertain the feasibility or desireability of building the routes. In this particular case the quotient is less than unity, 0.69, to indicate that existing and future economics will not support or qualify the whole routing for improvement.

V. RECOMMENDATIONS

On the basis of the previous analysis it is recommended that no attempt be made to build the Big Sandy - Hilger routing in whole. Such funds as are available should then be allocated to FAS Nos. 236 and 351, Hilger - Winifred and West, and Big Sandy South, respectively, since there is traffic presently on these sections sufficient to warrant such construction.